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AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

GCSE CHEMISTRY

H

Higher Tier Paper 1

Thursday 14 May 2020 Morning Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:
- a ruler
- a calculator
- the periodic table (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer all questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- In all calculations, show clearly how you work out your answer.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
TOTAL	

Information
- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

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Do not write outside the box

0 1 This question is about structure and bonding.

0 1 . 1 Which **two** substances have intermolecular forces between particles?

[2 marks]

Tick (✓) **two** boxes.

Intramolecular – within one molecule.
Intermolecular within two or more molecules.

Diamond	
Magnesium	
Poly(ethene)	✓
Sodium chloride	
Water	✓

- strong covalent bonds.

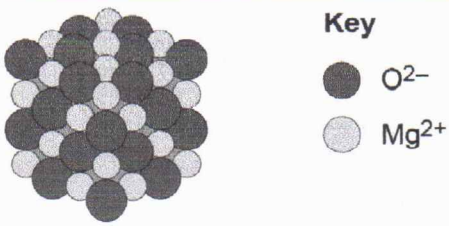
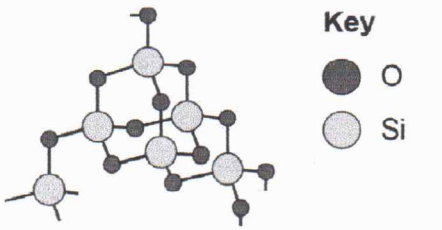
They have metallic bonds.

- strong ionic bonds thus strong electrostatic forces of attraction.

0 1 . 2 **Table 1** shows the structures of three compounds.

Table 1

Diagrams not to scale

Compound	Structure
Carbon dioxide	
Magnesium oxide	
Silicon dioxide	

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Compare the structure and bonding of the three compounds:

- carbon dioxide
- magnesium oxide
- silicon dioxide.

[6 marks]

Both carbondioxide and silicon dioxide are made up of atoms while magnesium oxide is made up of ions (Mg^{2+} and O^{2-}).

Both silicon dioxide and magnesium oxide are giant structures. For silicon dioxide is giant covalent structure and magnesium oxide is giant ionic structures.

Carbon dioxide and silicon dioxide forms covalent bonds by sharing pair of electrons while magnesium oxide forms ionic bond which involves transfer of electrons.

Both silicon dioxide and carbondioxide are formed between two non-metals while magnesium oxide is a bond of metal and non-metal.

8

Turn over for the next question

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0 2 This question is about metals and the reactivity series.

0 2 . 1 Which **two** statements are properties of most transition metals?

[2 marks]

Tick (✓) **two** boxes.

They are soft metals.		- Alkali metals are soft.
They form colourless compounds.		Forms coloured compounds.
They form ions with different charges.	✓	They have variable oxidation state
They have high melting points.	✓	
They have low densities.		- Transition have high densities

0 2 . 2 A student added copper metal to colourless silver nitrate solution.

The student observed:

- pale grey crystals forming
- the solution turning blue.

Explain how these observations show that silver is less reactive than copper.

[3 marks]

The pale grey crystals forming are indicating that it is silver. While the copper ions produced are blue. Using the reactivity series Copper displaces the less reactive silver.

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Do not write outside the box

0 2 . 3 A student is given three metals, **X**, **Y** and **Z** to identify.

The metals are magnesium, iron and copper.

Plan an investigation to identify the three metals by comparing their reactions with dilute hydrochloric acid.

Your plan should give valid results.

[4 marks]

You are required to add the Metals to dilute hydrochloric acid and then Measure the temperature change. For copper there will be no reaction and thus no temperature change as well as no bubbles are seen.

The reaction between Magnesium and iron, there is More Increase in temperature in Magnesium than in iron. The bubbles in Magnesium reacts faster than in iron. There will be a colourless solution of Magnesium chloride and a coloured solution of iron solution formed. We have to Maintain volume of acid and temperature same.

Question 2 continues on the next page

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Do not write outside the box

0 2 . 4 Metal **M** has two isotopes.

Table 2 shows the mass numbers and percentage abundances of the isotopes.

Table 2

Mass number	Percentage abundance (%)
203	30
205	70

Calculate the relative atomic mass (A_r) of metal **M**.

Give your answer to 1 decimal place.

[2 marks]

R.A.M = $\left(\frac{203 \times 30}{100}\right) + \left(\frac{205 \times 70}{100}\right)$

= 60.90 + 143.50

= 204.4

Relative atomic mass (1 decimal place) = 204.4

11

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0 3 This question is about silver iodide.

Silver iodide is produced in the reaction between silver nitrate solution and sodium iodide solution.

The equation for the reaction is:

$$AgNO_3(aq) + NaI(aq) \rightarrow AgI(s) + NaNO_3(aq)$$

0 3 . 1 A student investigated the law of conservation of mass.

This is the method used.

1. Pour silver nitrate solution into a beaker labelled **A**.
2. Pour sodium iodide solution into a beaker labelled **B**.
3. Measure the masses of both beakers and their contents.
4. Pour the solution from beaker **B** into beaker **A**.
5. Measure the masses of both beakers and their contents again.

Table 3 shows the student's results.

Table 3

	Mass before mixing in g	**Mass after mixing in g**
Beaker **A** and contents	78.26	108.22
Beaker **B** and contents	78.50	48.54

Explain how the results demonstrate the law of conservation of mass.

You should use data from **Table 3** in your answer.

[2 marks]

Required to obtain total mass before and after mixing.
Total Mass before = (78·26 + 78·50) = 156·76g.
Total Mass after = (108·22 + 4854) = 156·76g
The Mass of the products is equal to the Mass of the reactants, thus no change in Mass during the reaction.

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Do not write outside the box

0 3 . 2 Suggest how the student could separate the insoluble silver iodide from the mixture at the end of the reaction.

[1 mark]

Filtration

The student purified the separated silver iodide.

This is the method used.

1. Rinse the silver iodide with distilled water.

2. Warm the silver iodide.

0 3 . 3 Suggest **one** impurity that was removed by rinsing with water.

[1 mark]

- Sodium nitrate solution.
- Silver nitrate solution

0 3 . 4 Suggest why the student warmed the silver iodide.

[1 mark]

This was to remove the water in the silver iodide inorder to dry.

Question 3 continues on the next page

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Do not write outside the box

0 3 . 5 Calculate the percentage atom economy for the production of silver iodide in this reaction.

The equation for the reaction is:

$$AgNO_3(aq) + NaI(aq) \rightarrow AgI(s) + NaNO_3(aq)$$

Give your answer to 3 significant figures.

Relative formula masses (M_r): $AgNO_3 = 170$ $NaI = 150$ $AgI = 235$ $NaNO_3 = 85$

[4 marks]

Percentage atom economy = $\frac{\text{Total Mr of desired}}{\text{Total Mr. of all reactants}} \times 100\%$

M_r of reactants = $(170 + 150)$.

$= 320$

M_r of desired product (AgI)

% Atom economy = $\frac{235}{320} \times 100\%$

$= 73.4375$

$\simeq 73.4\%$

Percentage atom economy (3 significant figures) = 73.4 %

0 3 . 6 Give **one** reason why reactions with a high atom economy are used in industry.

[1 mark]

It uses fewer natural resources, Produce less waste and is better for the environment.

10

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0 4 This question is about electrolysis.

A student investigated the electrolysis of copper chromate solution.

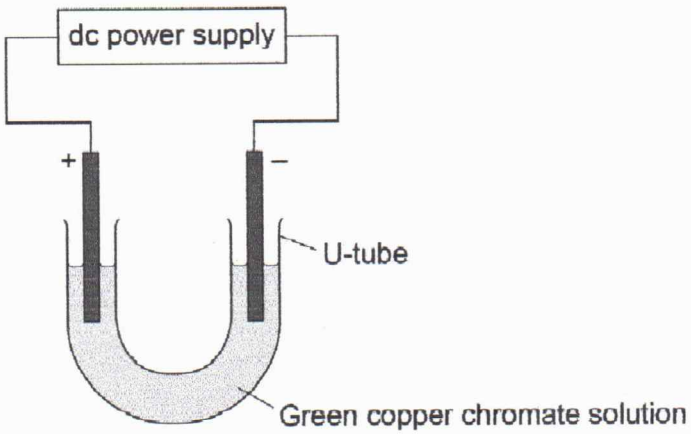
Copper chromate solution is green.

Copper chromate contains:

- blue coloured Cu^{2+} ions
- yellow coloured CrO_4^{2-} ions.

Figure 1 shows the apparatus used.

Figure 1



The student switched the power supply on.

The student observed the changes at each electrode.

Table 4 shows the student's observations.

Table 4

Changes at positive electrode	Changes at negative electrode
Solution turned yellow Bubbles formed at the electrode	Solution turned blue Solid formed on the electrode

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Do not write outside the box

0 4 . 1 Explain why the colour changed at the positive electrode.

[2 marks]

The chromate ions (CrO_4^{2-}) are negative ions and are attracted to the positive electrode. The colour change is for the ions.

0 4 . 2 The gas produced at the positive electrode was oxygen.

The oxygen was produced from hydroxide ions.

Name the substance in the solution that provides the hydroxide ions.

[1 mark]

Water

0 4 . 3 Describe how the solid forms at the negative electrode.

[3 marks]

The copper ions gain two electrons to form copper atoms.

$Cu^{2+} + 2e^- \longrightarrow Cu(s)$.

0 4 . 4 The student repeated the investigation using potassium iodide solution instead of copper chromate solution.

Name the product at each electrode when potassium iodide solution is electrolysed.

[2 marks]

Negative electrode: hydrogen

Positive electrode: iodine.

8

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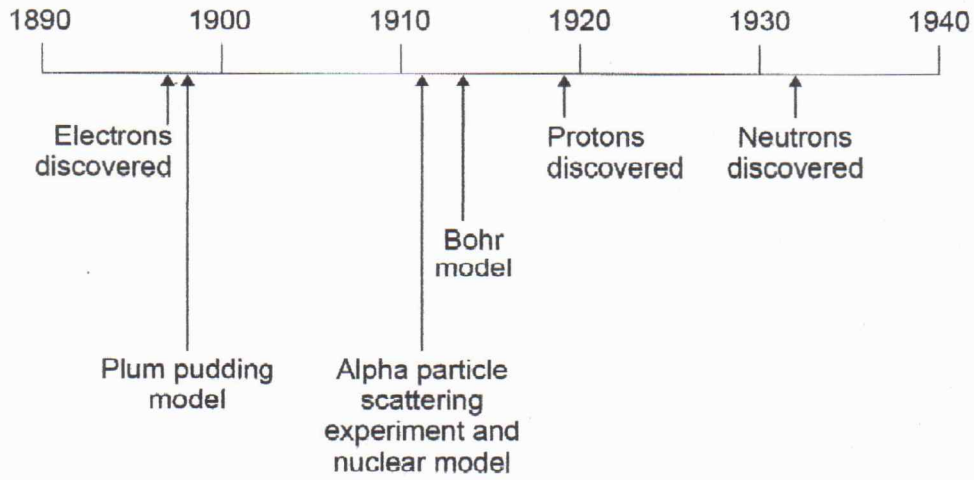
0 5 This question is about the development of scientific theories.

Figure 2 shows a timeline of some important steps in the development of the model of the atom.

Figure 2



0 5 . 1 The plum pudding model did not have a nucleus.

Describe **three** other differences between the nuclear model of the atom and the plum pudding model.

[3 marks]

1 The nuclear model is Mostly empty space while the Plum pudding model has no empty space.

2 The nuclear model has positive charge in the nucleus while plum pudding model is a ball of positive charge with embedded electrons.

3 The nuclear model, its mass is concentrated in the nucleus while plum pudding model the mass is spread out.

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Do not write outside the box

0 5 . 2 Niels Bohr adapted the nuclear model.

Describe the change that Bohr made to the nuclear model.

[2 marks]

The electrons orbit the nucleus and the electrons are at specific distances from the nucleus.

0 5 . 3 Mendeleev published his periodic table in 1869.

Mendeleev arranged the elements in order of atomic weight.

Mendeleev then reversed the order of some pairs of elements.

A student suggested Mendeleev's reason for reversing the order was to arrange the elements in order of atomic number.

Explain why the student's suggestion **cannot** be correct.

Use **Figure 2**.

[2 marks]

Atomic number is the number of protons and protons weren't discovered until later.

0 5 . 4 Give the correct reason why Mendeleev reversed the order of some pairs of elements.

[1 mark]

Their properties matched the rest of the group.

8

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0 6 This question is about displacement reactions.

0 6 . 1 The displacement reaction between aluminium and iron oxide has a high activation energy.

What is meant by 'activation energy'?

[1 mark]

Activation energy is the minimum amount of energy that particles must have inorder to react.

0 6 . 2 A mixture contains 1.00 kg of aluminium and 3.00 kg of iron oxide.

The equation for the reaction is:

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

Show that aluminium is the limiting reactant.

Relative atomic masses (A_r): O = 16 Al = 27 Fe = 56

[4 marks]

Relative Formula Mass of Fe_2O_3 = (56x2) + (16x3)
= 112 + 48
= 160

Number of Moles Fe_2O_3 = Mass / R.F.M

1kg = 1000g
3kg - ? 3000g

= 3000 / 160
= 18.75 Moles

Using Mole ratio 2Al : 1 Fe_2O_3

Moles of Al = 18.75x2
= 37 Mol

Aluminium is Limiting because 37.0 Mol is less than 18.75 Mol of Fe_2O_3. Iron oxide is in excess because 18.75 Mole is More.

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Magnesium displaces zinc from zinc sulfate solution.

0 6 . 3 Complete the ionic equation for the reaction.

You should include state symbols.

[2 marks]

$$Mg(s) + Zn^{2+}(aq) \rightarrow \underline{Mg^{2+}(aq)} + \underline{Zn(s)}$$

0 6 . 4 Explain why the reaction between magnesium atoms and zinc ions is both oxidation and reduction.

[2 marks]

Magnesium atoms are oxidised because they lose electrons while the zinc ions are reduced because they gain electrons.

9

Turn over for the next question

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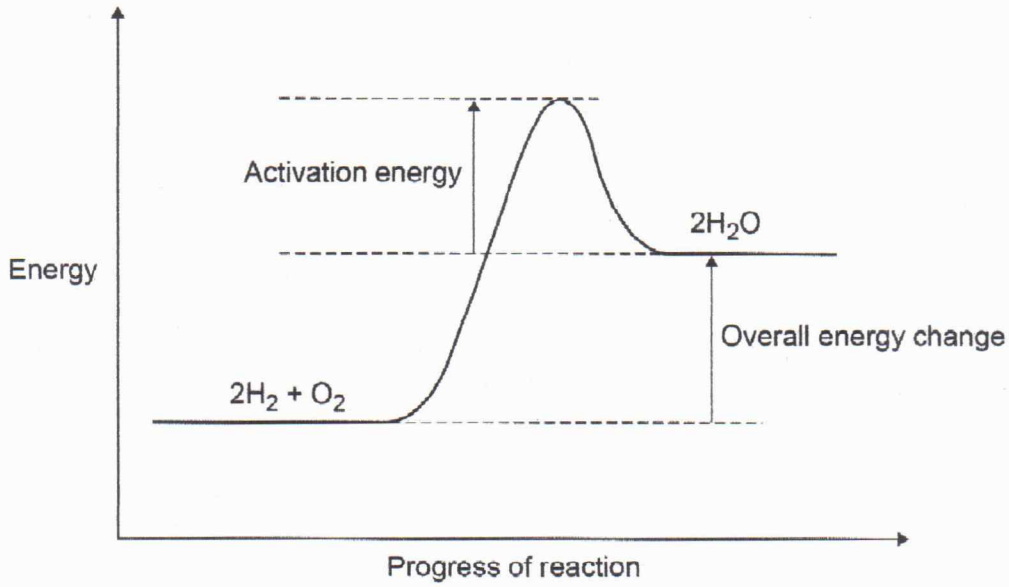
Do not write outside the box

0 7 The reaction between hydrogen and oxygen releases energy.

0 7 . 1 A student drew a reaction profile for the reaction between hydrogen and oxygen.

Figure 3 shows the student's reaction profile.

Figure 3



The student made **two** errors when drawing the reaction profile.

Describe the **two** errors.

[2 marks]

1 The activation energy should be from the reactants to the products.

2 The products have more energy than the reactants.

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0 7 . 2 The reaction between hydrogen and oxygen in a hydrogen fuel cell is used to produce electricity.

Hydrogen fuel cells and rechargeable cells are used to power some cars.

Give **two** advantages of using hydrogen fuel cells instead of using rechargeable cells to power cars.

[2 marks]

1 They are non-toxic chemicals to dispose at the end of the cell's life.

2 They take less time to refuel compared to rechargeable cells.

0 7 . 3 Reactions occur at the positive electrode and at the negative electrode in a hydrogen fuel cell.

Write a half equation for **one** of these reactions.

[1 mark]

$H_2 \longrightarrow 2H^+ + 2\bar{e}$

Question 7 continues on the next page

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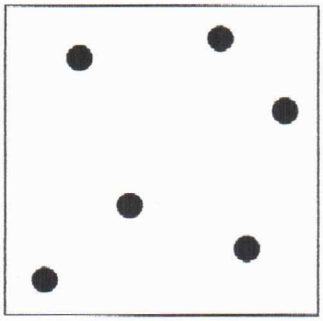
Do not write outside the box

0 7 . 4 The three states of matter can be represented by a simple particle model.

Figure 4 shows a simple particle model for hydrogen gas.

Figure 4



Give **two** limitations of this simple particle model for hydrogen gas.

[2 marks]

1 The hydrogen is not shown as a molecule (H_2).

2 The particles are shown as spheres.

- The particles does not show the movement (speed of particles).

0 7 . 5 The hydrogen gas needed to power a car for 400 km would occupy a large volume.

Suggest **one** way that this volume can be reduced.

[1 mark]

It can be required under high pressure.

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Do not write outside the box

0 7 . 6 The energy needed for a car powered by a hydrogen fuel cell to travel 100 km is 58 megajoules (MJ).

The energy released when 1 mole of hydrogen gas reacts with oxygen is 290 kJ

The volume of 1 mole of a gas at room temperature and pressure is 24 dm^3

Calculate the volume of hydrogen gas at room temperature and pressure needed for the car to travel 100 km

[4 marks]

1MJ = 10,000kJ

58MJ is equivalent to 58,000kJ

1Mole of any gas = $24dm^3$ $\frac{58000}{290}$

Number of Moles of hydrogen = $= 200$

1Mole → $24dm^3$

200Moles → ?

$\frac{200 \times 24}{1} = 4800 dm^3$

Volume of hydrogen gas = 4800 dm^3

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Turn over for the next question

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Do not write outside the box

0 8 This question is about the halogens.

Table 5 shows the melting points and boiling points of some halogens.

Table 5

Element	Melting point in °C	Boiling point in °C
Fluorine	–220	–188
Chlorine	–101	–35
Bromine	–7	59

0 8 . 1 What is the state of bromine at 0 °C **and** at 100 °C?

[1 mark]

Tick (✓) **one** box.

State at 0 °C	State at 100 °C	
Gas	Gas	☐
Gas	Liquid	☐
Liquid	Gas	✓
Liquid	Liquid	☐
Solid	Gas	☐
Solid	Liquid	☐

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Do not write outside the box

0 8 . 2 Explain the trend in boiling points of the halogens shown in **Table 5**.

[4 marks]

The boiling points of halogens increase going down the group. This is because of the molecules become larger and the intermolecular forces become stronger, thus more energy is needed to overcome these forces.

0 8 . 3 Why is it **not** correct to say that the boiling point of a single bromine molecule is 59 °C?

[1 mark]

The boiling point is related to intermolecular forces so more than one molecule is involved.

Question 8 continues on the next page

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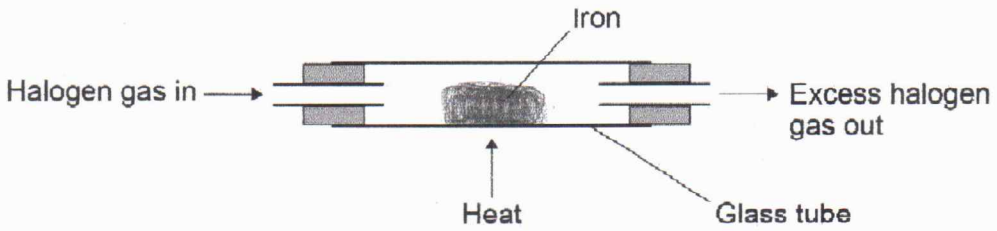
Do not write outside the box

Iron reacts with each of the halogens in their gaseous form.

Figure 5 shows the apparatus used.

Figure 5



0 8 . 4 Give **one** reason why this experiment should be done in a fume cupboard.

[1 mark]

The halogen gas produced is porsonous and so decreases blood capacity to flow.

0 8 . 5 Explain why the reactivity of the halogens decreases going down the group.

[3 marks]

When halogens are going down the group, their outer shell become further from the nucleus and the nucleus has less attraction for the outer shell, thus an electron is gained less easily.

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Do not write outside the box

0 8 . 6 A teacher investigated the reaction of iron with chlorine using the apparatus in **Figure 5**.

The word equation for the reaction is:

iron + chlorine → iron chloride

The teacher weighed:

- the glass tube
- the glass tube and iron before the reaction
- the glass tube and iron chloride after the reaction.

Table 6 shows the teacher's results.

Table 6

	Mass in g
Glass tube	51.56
Glass tube and iron	56.04
Glass tube and iron chloride	64.56

Calculate the simplest whole number ratio of:

moles of iron atoms : moles of chlorine atoms

Determine the balanced equation for the reaction.

Relative atomic masses (A_r): Cl = 35.5 Fe = 56

[6 marks]

Mass of Fe (iron) = 56.04 − 51.56
= 4.48 g

Mass of chlorine = 64.56 − 56.04
= 8.52 g

Number of Moles of Fe = $\frac{4.48}{56}$
= 0.08

Number of Moles of Cl = $\frac{8.52}{35.5}$ = 0.24

Fe	:	Cl
$\frac{0.08}{0.08}$	:	$\frac{0.24}{0.08}$
1	:	3

Moles of iron atoms : moles of chlorine atoms = 1 : 3

Equation for the reaction $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$

16

Turn over ▶

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0 9 This question is about citric acid ($C_6H_8O_7$).

Citric acid is a solid.

A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

This is the method used.

1. Pour 25 cm^3 of sodium hydrogencarbonate solution into a polystyrene cup.

2. Measure the temperature of the sodium hydrogencarbonate solution.

3. Add 0.20 g of citric acid to the polystyrene cup.

4. Stir the solution.

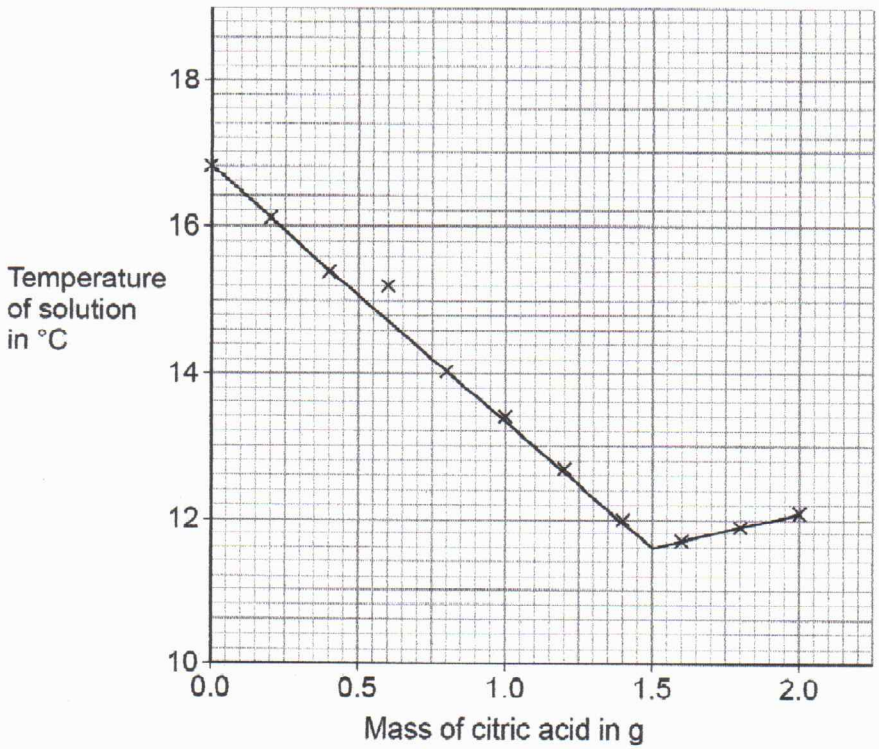
5. Measure the temperature of the solution.

6. Repeat steps 3 to 5 until a total of 2.00 g of citric acid has been added.

The student plotted the results on a graph.

Figure 6 shows the student's graph.

Figure 6



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0 9 . 1 **Figure 6** shows an anomalous point when 0.60 g of citric acid was added. This was caused by the student making an error.

The student correctly:

- measured the mass of the citric acid
- read the thermometer
- plotted the point.

Suggest **one** reason for the anomalous point.

[1 mark]

- The student didn't stir the solution enough.
- The temperature was measured before it stopped falling.

0 9 . 2 Explain the shape of the graph in terms of the energy transfers taking place.

You should use data from **Figure 6** in your answer.

[3 marks]

The temperature decreases initially because energy is taken in by the reaction from the solution (endothermic). When 1.5g of citric acid is added the sodium hydrogen carbonate has all reacted.

0 9 . 3 A second student repeated the investigation using a metal container instead of the polystyrene cup. The container and the cup were the same size and shape.

Sketch a line on **Figure 6** to show the second student's results until 1.00 g of citric acid had been added. The starting temperature of the solution was the same.

Explain your answer.

[3 marks]

The polystyrene cup is a better insulator, so more heat is absorbed from the surroundings.

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Do not write outside the box

The student used a solution of citric acid to determine the concentration of a solution of sodium hydroxide by titration.

0 9 . 4 The student made 250 cm^3 of a solution of citric acid of concentration 0.0500 mol/dm^3

Calculate the mass of citric acid ($C_6H_8O_7$) required.

Relative atomic masses (A_r): H = 1 C = 12 O = 16

[3 marks]

Number of Moles = $\frac{250 cm^3 \times 0.05}{1000}$

= 0.0125 moles

Mr. of citric acid = (12x6) + (8x1) + (16x7)

= 192

Mass of citric acid = No. of Moles x R.F.M

= 0.0125 x 192 = 2.49

Mass = 2.4 g

This is part of the method the student used for the titration.

1. Measure 25.0 cm^3 of the sodium hydroxide solution into a conical flask using a pipette.
2. Add a few drops of indicator to the flask.
3. Fill a burette with citric acid solution.

0 9 . 5 Describe how the student would complete the titration.

[3 marks]

You are required to add the citric acid to the flask (conical flask) until there is a permanent colour change. As you add drop by drop, swirl the solutions and then record the volume of acid added. Make recordings of final and Intial reading. Then obtain the average for concordant results.

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Do not write outside the box

0 9 . 6 Give **two** reasons why a burette is used for the citric acid solution.

[2 marks]

1 The burette has small increments (callibrations) that will ensure drop by drop addition.

2 Burette is more accurate compared to measuring cylinder.

0 9 . 7 13.3 cm^3 of 0.0500 mol/dm^3 citric acid solution was needed to neutralise 25.0 cm^3 of sodium hydroxide solution.

The equation for the reaction is:

$$3NaOH + C_6H_8O_7 \rightarrow C_6H_5O_7Na_3 + 3H_2O$$

Calculate the concentration of the sodium hydroxide solution in mol/dm^3

[3 marks]

No. of Moles citric acid = $\frac{\text{Volume} \times \text{Concentration}}{1000}$

$= \frac{13.3\ cm^3 \times 0.05}{1000}$

$= 0.000665$ Moles

Using Mole ratio 3 NaOH : 1 $C_6H_8O_7$

Moles of NaOH = 3×0.000665

$= 0.001995$ Moles

Concentration of NaOH = $\frac{1000 \times 0.001995}{1000}$

$= 0.0798\ mol/dm^3$

Concentration = 0.0798 mol/dm^3

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END OF QUESTIONS